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Travel-associated non-typhoidal salmonellosis: geographical and seasonal differences and serotype distribution

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ABSTRACT

The Swedish database on notifiable communicable diseases was used to identify 24 803 cases of travel-associated non-typhoidal salmonellosis from the period 1997–2003. Serotype data were available for 24 358 (98.2%) of these cases, which were compared with a data set from the same period of 16 255 randomly selected Swedish residents with a history of recent overnight travel outside Sweden. The highest risk of disease was seen in travellers returning from East Africa (471/100 000 travellers; 95% CI 294–755), or the Indian subcontinent (474/100 000; 95% CI 330–681). Children aged 0–6 years were at higher risk than travellers of other ages (OR 2.4; 95% CI 2.1–2.8). Some distinct seasonal patterns could be distinguished, with highest (adjusted) risk in December in East Asia, and in August in Europe. Marked geographical differences in serotype distribution were noted. *Salmonella* Enteritidis was especially dominant in Europe, but was much less common in Africa, Asia and America, where the variety of circulating serotypes was greater. Overall, the two data sets provided important information on travel risks which are also likely to apply to travellers from other western countries.

Keywords Risk factors, salmonellosis, seasonal variations, serotypes, travel risks

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INTRODUCTION

International travel has grown vastly in the last few decades. Approximately 80 million people travel each year to Africa, Asia, the Pacific Islands, Latin America and remote areas of eastern Europe [1]. One downside of this interconnected 'global village' is an increasing risk of contracting infectious diseases, especially gastrointestinal disease [2]. Infections caused by *Salmonella* spp., as well as infections caused by enterotoxigenic *Escherichia coli* (ETEC), *Campylobacter* spp. and *Shigella,* are a major cause of travellers' diarrhoea [3–6]. Using the Kauffman–White criteria for antisera reaction to different bacterial O and H antigens, more than 2500 *Salmonella* serovars associated with non-typhoidal salmonellosis (all serotypes of *Salmonella enterica* except *Salmonella* serovar Typhi and *Salmonella* serovar Paratyphi) have been identified [4]. In the developed world, salmonellosis is associated most often with consumption of poultry and eggs [5,6]. The infective dose is usually high, but the bacteria grow well in most foodstuffs. Susceptibility to infection varies, with a lower critical infective dose in infants, as well as elderly or compromised hosts [7]. No vaccine is available for non-typhoidal salmonellosis.

Surveillance statistics on travel-related infections, without denominator data on travel, will largely reflect the travelling pattern, rather than the risk of disease in different countries. This report therefore used notification data and a unique database on travel patterns to give a detailed estimate of the risk of contracting these diseases in various regions of the world, and to investigate the serotype epidemiology in returning travellers from various countries.

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PATIENTS AND METHODS

Notification data on salmonellosis

Salmonellosis is a notifiable disease in Sweden and is reported to the Swedish Institute for Infectious Disease Control (SMI) both by the physician caring for the patient (clinical notification) and by the laboratory that diagnoses the causative agent (laboratory notification). Clinical and laboratory reports for each patient are merged at the SMI, using a unique personal identification number. Newly arrived immigrants and refugees can be identified from this number. The clinical notifications also include information of epidemiological relevance, such as route of infection, risk group, and the likely place and country of infection.

For this study, notification data for the period January 1997 to December 2003 were used. All records in the national surveillance database concerning notified patients with non-typhoidal salmonellosis were retrieved. Patients with stated domestically-acquired infection, or patients for whom information on the likely country of infection was either missing or 'unknown' were excluded. The data set was also 'cleansed' of infections involving recently arrived immigrants and refugees.

Denominator data on travel patterns (the Tourist Database)

As a denominator for travel patterns, a commercial database, the Swedish Travel and Tourist Database (TDB) was used [7]. This data set is based on a randomised selection of 2000 members of the Swedish population who are interviewed by telephone each month with questions regarding all (business and pleasure) recent (previous month) travel. The data are then weighted and extrapolated to give an estimate of the total number of Swedish travellers. From the total database, containing data from almost 170 000 interviews, 16 255 records from respondents with a history of recent overnight travel outside Sweden were extracted. Data on the principal country/geographical area of travel, age and gender, and month of travel were used for analysis. No data on any illness are available from this data set. For this study, both the actual number of respondents with a travel history abroad and the extrapolated total numbers of travellers were used.

Serotyping

All isolates of *Salmonella* from Swedish microbiology laboratories are sent to the SMI for serotyping. Serotyping of the isolates was performed by agglutination using antiserum from Reagensia (Stockholm, Sweden). Interpretation of serotypes was made according to the latest edition of the Kauffman–White scheme from the WHO international reference laboratory [8].

Statistical methods

The risk of disease per 100 000 travellers was calculated using notification data on the single diseases as the numerator, and the estimated total numbers of travellers from the TDB as the denominator. The actual number of individuals interviewed was used to calculate 95% confidence intervals (95% CI) for the estimates.

Odds ratios (OR) with corresponding 95% CI were calculated to assess the risk factors (age, gender, month and travel destination) for being notified with disease. The respondents in the TDB were used as controls (with the lowest incidence in each category used as the reference). To adjust for confounding and test for interaction, a logistic regression model was used, which included as variables the country/area of destination, age, gender and month. For each region, the OR for disease/month were analysed, adjusted for age, gender, and number of cases/travellers. All analyses were made using the Stata 6.0 software (Stata Corporation, College Station, TX, USA).

Ethical considerations

The TDB contains aggregated data only. Notification data is regulated by the Swedish Communicable Disease Act, and contains full personal identification. The subset of the notification database extracted for this study did not contain any information that could be linked to a specific person. The study was approved by the Medical Ethics Committee of the Karolinska Institute, Stockholm, Sweden.

RESULTS

Travel pattern

The 16 255 respondents in the TDB with overnight travel to different regions during the study period 1997–2003 formed the basis for the estimates of travel to different regions. The travel histories from the respondents were weighted and projected to give an estimate of the number of journeys (Table 1). According to these estimates, Swedish travellers made *c*.68 million overnight journeys to the different countries/regions (78% leisure trips and 22% business trips) during the period of the study.

Salmonella notifications

During the study period, notification of 31 679 patients with salmonellosis was received (Table 2). Most of these infections (24 803; 78%) were travel-associated, with cases associated with travel to 151 different countries. The total number of notified travel-associated cases of salmonellosis from single countries mainly reflected the travel pattern of Swedes and, to a lesser extent, the risk of disease in the various countries (Table 1). The ten countries stated most often as the country of infection were, in descending order, Spain (n = 6156), Thailand (n = 4594), Greece (n = 1885), Turkey (n = 1391), Tunisia (n = 733), Poland (n = 657), Morocco (n = 643), Portugal (n = 605), Cyprus (n = 560) and Indonesia (n = 525).

Age/Gender/ Region[a]	Estimated no. of travellers	Controls	Notified cases	Risk/ 100 000	95% CI	Multivariate odds ratio	95% CI
Total	67 870 000	16 255	24 803	36.5	35.8–37.3	–	–
0–6 years	3 300 000	524	1763	53.4	48.5–58.9	2.3	2.0–2.7
7–18 years	8 150 000	1599	2933	36.0	33.9–38.2	1.4	1.2–1.6
19–45 years	30 520 000	6708	10 942	35.9	34.8–37.0	1.2	1.1–1.3
46–65 years	21 850 000	5990	7728	35.4	34.2–36.6	1.0	0.9–1.1
>65 years	4 050 000	1434	1441	35.6	33.1–38.3	1.0	Reference
Men	36 020 000	8145	12 357	34.3	33.4–35.3	1.1	1.0–1.1
Women	31 850 000	8110	12 446	39.1	38.0–40.2	1.0	Reference
Nordic countries	22 730 000	5350	397	1.7	1.6–1.9	1.0	Reference
Western Europe	14 800 000	3584	1119	7.6	7.1–7.8	4.6	4.1–5.2
Southern Europe	12 070 000	2931	7202	59.7	57.2–62.3	38.2	34.1–42.8
Eastern Europe (incl. Baltic Republics)	3 320 000	818	1945	58.6	54.0–63.6	32.2	28.2–36.8
Eastern Mediterranean	7 740 000	1817	4185	54.1	51.2–57.1	27.7	24.6–31.2
Russia and former USSR	260 000	59	100	38.5	27.9–53.1	24.7	17.5–34.8
Arabian countries and Iran	220 000	44	282	128	93–176	71.5	50.9–100.4
India with neighbours	120 000	31	569	474	330–681	310	212–453
East Asia	2 050 000	517	5535	270	247–295	198	172–228
Australia, New Zealand and the Pacific	450 000	116	46	10.2	7.3–14.4	6.9	4.8–9.9
North Africa	770 000	196	1794	233	201–271	151	126–181
West Africa	80 000	22	223	279	180–432	176	112–276
East Africa	90 000	18	424	471	294–755	405	249–658
Central Africa	30 000	8	28	93.3	42.5–204.8	47.0	21.1–104.8
Southern Africa	170 000	42	117	68.8	48.4–97.9	50.0	34.5–72.5
North America	2 170 000	503	55	2.5	1.9–3.3	1.7	1.2–2.3
Central America	170 000	43	183	108	77–150	70.0	49.2–99.5
Caribbean	380 000	95	408	107	86–134	73.1	57.0–93.9
South America	250 000	61	199	79.6	59.7–106.0	59.9	43.9–81.6

[a]Nordic countries: Denmark, Finland, Iceland, Norway; Western Europe: Austria, Belgium, France, Germany, Ireland, Luxembourg, the Netherlands, Switzerland, UK; Southern Europe: Italy, Malta, Monaco, Portugal, Spain; Eastern Europe: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia; Eastern Mediterranean: Albania, Cyprus, former Yugoslavia, Greece, Israel, Turkey; Russia and former USSR: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan; Arabian countries and Iran: Bahrain, Iraq, Iran, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen; India with neighbours: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka; East Asia: Brunei, Burma, Cambodia, China, Hong Kong, Indonesia, Japan, Laos, Malaysia, Mongolia, North Korea, Philippines, South Korea, Singapore, Taiwan, Thailand, Tibet, Vietnam; Australia: New Zealand and the Pacific, American Samoa, Australia, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Micronesia, Nauru, New Caledonia, New Zealand, Niue, Palau, Papua New Guinea, Samoa, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna; North Africa: Algeria, Egypt, Libya, Morocco, Tunisia; West Africa: Benin, Burkina Faso, Cape Verde, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Mauritania, Senegal, Sierra Leone, The Gambia, Togo; East Africa: Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Seychelles, Somalia, Sudan, Tanzania, Uganda; Central Africa:, Cameroon, Central African Republic, Chad, Congo Brazzaville, Equatorial Guinea, Gabon, Niger, Nigeria, Republic of Congo, São Tomé et Principe; Southern Africa: Angola, Botswana, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Zambia, Zimbabwe; North America: Canada, USA; Central America: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama; Caribbean: Antigua and Barbuda, Bahamas, Barbados, Bermuda, Cayman Islands, Cuba, Dominica, Dominican Republic, Grenada, Guadeloupe, Jamaica, Haiti, Martinique, Netherlands Antilles, Puerto Rico, St. Christopher and Nevis, St. Lucia/St. Vincent, St. Kitts-Nevis, The Grenadines, Trinidad and Tobago, Virgin Islands; South America: Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Honduras, Paraguay, Peru, Suriname, Uruguay, Venezuela.

Table 1 Estimated number of travellers, respondents in the Swedish Travel and Tourist Database (controls) and notified cases with travel-associated non-typhoidal salmonellosis (1997–2003), with an unadjusted risk estimate/100 000 and multivariate odds ratios from a logistic regression model adjusted for the risk factors of age, gender, month of travel and travel destination

Table 2. Notified cases of non-typhoidal salmonellosis in Sweden (1997–2003)

Disease and category of infection	1997	1998	1999	2000	2001	2002	2003	1997–2003
Infected in Sweden	595	453	947	678	671	818	805	4967
Travel-associated	3569	3829	3923	3893	3819	2930	2840	24 803
Immigrants/refugees	81	77	40	42	8	9	10	267
Unknown	455	235	231	235	214	133	139	1642
Total	4700	4594	5141	4848	4712	3890	3794	31 679

Risk factors

The overall risk of being notified with salmonellosis was 36.5/100 000 travellers. The lowest risk was seen in the Nordic countries (1.7/100 000 travellers); this region was therefore used as the reference in the further logistic regression model, where the relative risks for various countries were adjusted for age, gender, and month of travel. The highest individual risk was seen in developing countries, specifically East Africa (OR 405; 95% CI 249–658), India and neighbouring countries (OR 310; 95% CI 212–453), East Asia (OR 198; 95% CI 172–228), and West Africa (OR 176; 95% CI 112–277). The risk decreased with increasing age. Gender was not associated with a higher risk of being notified with salmonellosis (Table 1).

Serotype distribution

Of the 24 803 episodes of travel-associated salmonellosis, serotype data were available for 24 358 (98.2%) episodes. In total, 202 different serotypes

were represented among the notified cases during the period. Distinct regional variations in serotype distribution were noted (Table 3). Although it was the most common serotype in most regions of the world, *Salmonella* Enteritidis was especially dominant in Europe, where more than two-thirds of all cases of salmonellosis were caused by this serotype. In Africa, Asia and America, this serotype was far less dominant, and the variety of other circulating serotypes was greater.

Seasonality

The seasonal pattern varied between different regions of the world. In most regions, the number of cases was too small for a detailed analysis of seasonality. Therefore, the analysis concentrated on: (i) the Nordic countries and western Europe (1516 cases); (ii) the Mediterranean region, including southern Europe, eastern Mediterranean and North Africa (13 181 cases); and (iii) East Asia (5535 cases). The adjusted ORs for *Salmonella* infection/month in these three regions are shown in Fig. 1. Some distinct seasonal patterns could be distinguished, with the highest risks existing during June–September in Europe, and in November–December in East Asia. The seasonality was more marked in northern/western Europe than in the Mediterranean region.

DISCUSSION

Reliable denominator data on travel are essential for calculating the risks of travel-related disease in various parts of the world [9]. In most countries, travel statistics are based on official figures for the first destination of international air travel. Since many Swedish long-distance passengers change flights in the large airports at Copenhagen, Frankfurt, Amsterdam, London and Paris, the official statistics overestimate travel to these countries and greatly underestimate travel to subsequent destinations in Africa, Asia and South America.

In contrast, the TDB gives information on each country/region visited for at least one overnight stay. This provides a unique opportunity to relate surveillance data to a more appropriate travel denominator, as has been done previously for dengue fever [10] and rickettsiosis [11].

The data presented in this study concern Swedish travellers, and the travel patterns of

Table 3. Serotype distribution of the ten most common *Salmonella* serotypes/region (1997–2003)

Region/serotype	Distribution (*n*, %)
Nordic countries (*n* = 389)	
S. Enteritidis	249 (64.0)
S. Typhimurium	68 (16.5)
S. Infantis	16 (4.1)
S. Virchow	5 (1.3)
S. Hadar	4 (1.0)
S. Oranienburg	4 (1.0)
S. Newport	3 (0.8)
S. Stanley	3 (0.8)
S. Agona	2 (0.5)
S. Saintpaul	2 (0.5)
Others (*n* = 21)	33 (8.5)
Western Europe (*n* = 1099)	
S. Enteritidis	826 (75.2)
S. Typhimurium	116 (10.6)
S. Virchow	15 (1.4)
S. Hadar	12 (1.1)
S. Infantis	9 (0.8)
S. Newport	6 (0.5)
S. Blockley	6 (0.5)
S. Braenderup	6 (0.5)
S. Indiana	6 (0.5)
S. Heidelberg	4 (0.4)
Others (*n* = 35)	93 (8.5)
Southern Europe (*n* = 7089)	
S. Enteritidis	5616 (79.2)
S. Typhimurium	564 (8.0)
S. Hadar	115 (1.6)
S. Virchow	87 (1.2)
S. Newport	41 (0.6)
S. Infantis	29 (0.4)
S. Heidelberg	22 (0.3)
S. Montevideo	16 (0.2)
S. Braenderup	14 (0.2)
S. Muenchen	14 (0.2)
Others (*n* = 75)	571 (8.1)
Eastern Europe (*n* = 1881)	
S. Enteritidis	1467 (78.0)
S. Typhimurium	148 (7.9)
S. Hadar	73 (3.9)
S. Saintpaul	23 (1.2)
S. Infantis	21 (1.1)
S. Agona	18 (1.0)
S. Virchow	9 (0.5)
S. Blockley	7 (0.4)
S. Derby	7 (0.4)
S. Corvallis	6 (0.3)
Others (*n* = 37)	102 ()
Eastern Mediterranean (*n* = 4096)	
S. Enteritidis	2425 (59.2)
S. Typhimurium	319 (7.8)
S. Virchow	294 (7.1)
S. Agona	107 (2.6)
S. Hadar	96 (2.3)
S. Infantis	47 (1.1)
S. Oranienburg	45 (1.1)
S. Montevideo	40 (1.0)
S. Mbandaka	33 (0.8)
S. Anatum	22 (0.5)
Others (*n* = 79)	1422 (34.7)
Russia and former USSR (*n* = 98)	
S. Enteritidis	71 (72)
S. Typhimurium	10 (10)
S. Kottbus	4 (4)
S. Muenchen	2 (2)
S. Hadar	1 (1)
S. Agona	1 (1)
S. Bareilly	1 (1)
S. Isangi	1 (1)
S. London	1 (1)
S. Virchow	1 (1)
Others (*n* = 4)	4 (4)
Arabian countries and Iran (*n* = 275)	
S. Enteritidis	61 (22.2)
S. Typhimurium	44 (16.0)
S. Agona	16 (5.8)
S. Infantis	15 (5.5)

(continued)

Table 3. Continued

Region/serotype	Distribution (*n*, %)
S. Blockley	13 (4.7)
S. Montevideo	9 (3.3)
S. Newport	6 (2.2)
S. Mbandaka	5 (1.8)
S. Oranienburg	4 (1.5)
S. Anatum	3 (1.1)
Others (*n* = 44)	99 (36.0)
India and neighbours (*n* = 560)	
S. Typhimurium	68 (12.1)
S. Enteritidis	67 (12.0)
S. Bareilly	66 (11.8)
S. Virchow	58 (10.4)
S. Braenderup	45 (8.0)
S. Newport	22 (3.9)
S. Oslo	21 (3.8)
S. Stanley	18 (3.2)
S. Mbandaka	17 (3.0)
S. Worthington	12 (2.1)
Others (*n* = 40)	166 (29.6)
East Asia (*n* = 5463)	
S. Enteritidis	826 (15.1)
S. Stanley	609 (11.1)
S. Hadar	470 (8.6)
S. Virchow	403 (7.4)
S. Panama	293 (5.4)
S. Newport	195 (3.6)
S. Agona	165 (3.0)
S. Typhimurium	144 (2.6)
S. Java	132 (2.4)
S. Rissen	131 (2.4)
Others (*n* = 86)	2095 (38.3)
Australia, New Zealand, Pacifics (*n* = 45)	
S. Enteritidis	11 (24)
S. Hadar	6 (13)
S. Typhimurium	6 (13)
S. Oranienburg	4 (9)
S. Virchow	3 (7)
S. Brandenburg	2 (4)
S. Java	2 (4)
S. Javiana	2 (4)
S. Panama	2 (4)
S. Thompson	2 (4)
Others (*n* = 5)	5 (11)
North Africa (*n* = 1755)	
S. Enteritidis	600 (34.2)
S. Typhimurium	178 (10.1)
S. Hadar	131 (7.5)
S. Virchow	97 (5.6)
S. Braenderup	60 (34.2)
S. Blockley	52 (3.0)
S. Infantis	48 (2.7)
S. Haifa	42 (2.4)
S. Anatum	41 (2.4)
S. Livingstone	34 (1.9)
Others (*n* = 57)	472 (26.9)
West Africa (*n* = 220)	
S. Virchow	44 (20.0)
S. Stanleyville	21 (9.5)
S. Enteritidis	14 (6.4)
S. Hull	13 (5.9)
S. Typhimurium	9 (4.1)
S. Chester	6 (2.7)
S. Mbao	4 (1.8)
S. Grumpenisis	4 (1.8)
S. Oranienburg	4 (1.8)
S. Tyresoe	4 (1.8)
Others (*n* = 57)	97 (44.1)
Central Africa (*n* = 26)	
S. Colindale	3 (12)
S. Enteritidis	2 (8)
S. Chester	2 (8)
S. Coeln	1 (4)
S. Hadar	1 (4)
S. Heidelberg	1 (4)
S. Infantis	1 (4)
S. Plymouth	1 (4)
S. Stanleyville	1 (4)
S. Typhimurium	1 (4)

Table 3. Continued

Region/serotype	Distribution (*n*, %)
Others (*n* = 12)	12 (5)
East Africa (*n* = 415)	
S. Enteritidis	92 (22.2)
S. Typhimurium	33 (8.0)
S. Heidelberg	32 (7.7)
S. Newport	28 (67.5)
S. Braenderup	27 (6.5)
S. Virchow	16 (3.9)
S. Agona	12 (2.9)
S. Hadar	12 (2.9)
S. Oranienburg	11 (2.7)
S. Haifa	9 (2.2)
Others (*n* = 61)	143 (34.5)
Southern Africa (*n* = 114)	
S. Enteritidis	20 (17.5)
S. Typhimurium	20 (17.5)
S. Virchow	11 (9.6)
S. Muenchen	7 (6.1)
S. Braenderup	3 (2.6)
S. Heidelberg	3 (2.6)
S. Infantis	3 (2.6)
S. Newport	3 (2.6)
S. Agona	2 (1.7)
S. Isangi	2 (1.7)
Others (*n* = 29)	40 (35.1)
North America (*n* = 54)	
S. Typhimurium	16 (29)
S. Enteritidis	6 (11)
S. Newport	4 (7)
S. Heidelberg	3 (6)
S. Javiana	3 (6)
S. Agona	2 (4)
S. Litchfield	2 (4)
S. Schwarzengrund	2 (4)
S. Hadar	2 (4)
S. Infantis	1 (2)
Others (*n* = 13)	13 (24)
Central America (*n* = 179)	
S. Agona	28 (15.6)
S. Enteritidis	24 (13.4)
S. Typhimurium	18 (10.1)
S. Infantis	15 (8.4)
S. Panama	11 (6.1)
S. Javiana	6 (3.4)
S. Newport	6 (3.4)
S. Sandiego	5 (2.8)
S. Braenderup	4 (2.2)
S. Heidelberg	4 (2.2)
Others (*n* = 26)	58 (32.4)
Caribbean (*n* = 402)	
S. Enteritidis	223 (55.5)
S. Typhimurium	28 (7.0)
S. Infantis	19 (4.7)
S. Agona	12 (3.0)
S. Newport	9 (2.2)
S. Senftenberg	7 (1.7)
S. Braenderup	6 (1.5)
S. Heidelberg	6 (1.5)
S. Derby	5 (1.2)
S. Uganda	5 (1.2)
Others (*n* = 31)	76 (18.9)
South America (*n* = 198)	
S. Enteritidis	45 (22.7)
S. Saintpaul	39 (19.7)
S. Newport	22 (11.1)
S. Agona	7 (3.5)
S. Infantis	5 (2.5)
S. Javiana	5 (2.5)
S. Albany	4 (2.0)
S. Heidelberg	4 (2.0)
S. Montevideo	4 (2.0)
S. Typhimurium	4 (2.0)
Others (*n* = 32)	58 (29.3)

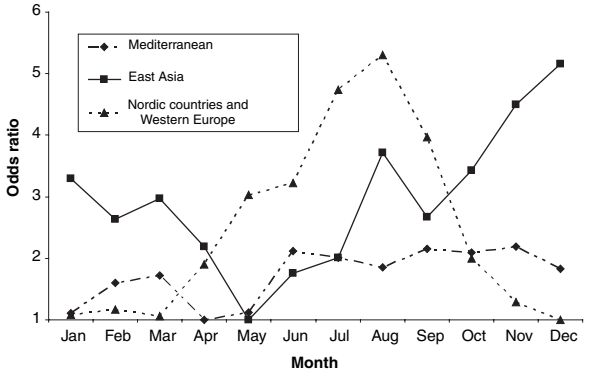

Fig. 1. Seasonal pattern of notified cases of travel-associated non-typhoidal salmonellosis (1997–2003). The monthly odds ratios (OR) for *Salmonella* notifications are adjusted for age, gender and number of travellers in a multivariate logistic regression model. The OR should be interpreted as the relative risk compared with the month with the lowest risk, estimated for each region separately (a theoretical region with the same risk each month would then have OR of 1.0 for each month – regardless of the number of cases).

individuals from other western countries may differ from those of Swedes. However, since the results have been adjusted for age, gender, and month of travel, and the estimates of risk are related to the number of Swedes travelling to different countries, the main conclusions should also be valid for travellers from other western countries to those areas for which there is enough statistical power to detect elevated risks.

No data on travel-related illnesses in the controls were available from the TDB, so the possibility that the control group could also have included individuals who had experienced disease during their travel cannot be excluded. However, all calculations were based on the odds of being notified in Sweden after returning home, and not on the odds of falling ill (for which no data were available). Considering the small number of notified cases and controls in relation to the total estimated number of travellers, it would be unlikely that any single person would be included both as a patient and as a control.

In most countries, as in Sweden, official data on travel-related infections give the number of infections/country, without relating these figures to travel statistics. In this way, the figures are better suited to reflect travel patterns than to give useful information on the risk of contracting disease in various regions of the world. Therefore, the data from the present study better reflect the relative risks of contracting salmonellosis in different travel destinations. Since Sweden has a uniform national system for reporting infectious diseases, and the notification database is based on both clinical and laboratory notifications, the sensitivity of the notification system is comparatively good. Using the capture-recapture technique [12] to estimate the proportion of cases being reported by either clinicians or laboratories, >99% of all diagnosed *Salmonella* infections were reported each year during the period 1998–2002 [13]. However, notification data only represent a small minority of all diseases experienced by travellers. Salmonellosis is an acute, usually self-limited disease. Most cases are never attended by a physician, and even fewer are investigated microbiologically after return to Sweden. The actual number of individuals infected by *Salmonella* is likely to be more than ten-fold the number presented here.

The study design only allowed for detection of cases diagnosed after return to Sweden. The notification data should therefore reflect what happened during the last week of stay in each respective country. If, as suggested previously, the risk of travellers' diarrhoea is higher during the first 2 weeks in a highly endemic area [1, 14], the calculated risks may be underestimated in travel destinations involving a more prolonged stay. However, individuals staying for long periods abroad are also less likely to be interviewed by telephone in Sweden, thereby compensating for the missed cases.

In the present study, certain regions of the world stood out as special high-risk areas for contracting salmonellosis. These areas include East Africa and the Indian subcontinent, consistent with previous reports on traveller's diarrhoea [15,16,], and also East Asia. Large variations in odds ratios were seen within the African continent. Although based on small numbers, these differences were significant, and the reasons for these variations require further investigation.

Trips to neighbouring countries also pose some risk. Very rigorous control methods mean that Sweden has an extremely low domestic incidence of salmonellosis [17,18]. At least 75% of all notified episodes of salmonellosis in Sweden are travel-related. Even in neighbouring Denmark, the situation is reversed, with only 25% of cases involving the most common serotype, *Salmonella* Enteritidis, being related to travel [19]. Efforts to

further decrease the incidence of salmonellosis in Swedish residents should therefore focus on imported food and on travel advice, including close destinations.

Young age was a significant risk factor for salmonellosis, with the individual risk decreasing with increasing age. It has been suggested previously [6] that the elevated risk in the youngest part of the population is associated with increased faecal/oral contamination and decreased immunity, and that the high risk in young adults is associated with ingestion of larger volumes of potentially contaminated food and an adventurous lifestyle.

The study showed large variations in serotype distribution between different regions. *Salmonella* Enteritidis, which is often associated with egg and poultry consumption [8,9], was among the most common serotypes in all regions, but was most dominant in Europe (*c*.70% of cases compared with only 11% of cases in North America). Serotypes were much more heterogenous in tropical countries than in temperate regions, indicating the higher impact of a local flora, and probably also reflecting a less-developed food distribution system over large geographical areas. Since the seasonal distribution of ORs for disease was adjusted for age, gender and the number of travellers, the differing seasonal patterns between the regions should reflect a true seasonality of the disease risk. However, an alternative explanation could be that travellers with different risk behaviours visit these regions at different times of the year.

Overall, the present study demonstrated that crude data regarding the country of notified infection are less-suited to predict the risk of disease in various travel destinations. In order to be useful, the data should be related to a travel denominator. Such denominator-based information could form the basis for pre-travel advice. In addition to patients at medical risk, groups that are especially likely to benefit from such advice are young people and parents of small children travelling to Africa and to the Indian subcontinent.

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